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Lawrence Berkeley National Laboratory Report

ASHRAE 110 Tracer Gas Containment Test

Prototype Berkeley Hood;

"Final" Configuration

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Conducted at Lawrence Berkeley National Laboratory

Overview

The ASHRAE Guideline, ANSI/ASHRAE 110- 1995, Method of Testing Performance of Laboratory Fume Hoods is the foremost protocol used to perform laboratory-type fume hood tests. The following containment testing used portions of the ASHRAE 110 protocol. The ASHRAE-110 Method of Performance for Laboratory Fume Hoods is an elaborate, three-part test that involves face velocity testing, flow visualization, and a tracer gas test.

Researchers at Lawrence Berkeley National Laboratory (LBNL) are developing a containment technology that reduces required airflow through laboratory fume hoods, but does not rely on face velocity, in the traditional sense, to maintain fume containment within a hood. Therefore, ASHRAE 110 face velocity tests were not performed. LBNL's High-Performance Laboratory Fume Hood, referred to in this document as "the Berkeley hood," incorporates this innovative technology that provides containment at 50 to 70 percent lower airflow than a typical fume hood.

The LBNL containment technology uses a "push-pull" displacement airflow approach to contain fumes and move air through a hood. Displacement air "push" is introduced with supply vents near the hood's sash opening. Displacement air "pull" is provided by simultaneously exhausting air from the hood. Thus, an "air divider" is created, between an operator and a hood's contents, that separates and distributes airflow at the sash opening. This air divider technology is simple, protects an operator, and delivers dramatic cost reductions in a facility's construction and operation.

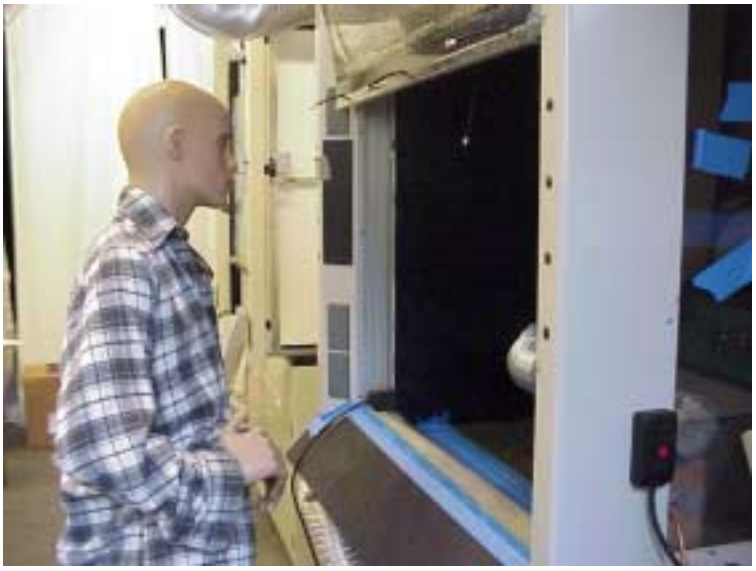
Description of Laboratory-Type Hood

Dr. Helmut Feustel, a LBNL staff researcher, developed basic concepts for a High-Performance Laboratory Fume Hood during 1995–1998. In January 1999, LBNL's Environmental Energy Technologies Division (EETD) transferred the project to its Applications Team. At this time, the research project team developed a "prototype" Berkeley hood.

"Final" Prototype Berkeley Hood

The prototype hood was built with a superstructure provided by Labconco. By August 2000, it was modified and evaluated extensively over a period of nearly two years before this series of containment tests were performed. This incarnation represented the "final" Berkeley hood configuration (LPx) both dimensionally and functionally. This design information was transferred to Labconco. They proceeded to build an "alpha" version of the Berkeley hood for the UCSF demonstration project. Containment test results from this alpha hood are presented in another report.

Prototype Berkeley Hood



Prototype Berkeley Hood.

Description of Test Procedure

LBNL researchers successfully applied two of the ASHRAE 110 test methods, flow visualization and tracer gas tests. These two tests are outlined below:

1) Flow visualization tests can be performed with various smoke-generating substances. Theatrical smoke, superheated glycol, smoke "sticks," titanium tetrachloride, and dry ice, solid-phase CO2, are examples of smoke sources. A qualitative understanding of containment is gained from conducting smoke tests. A rating system has been devised for "poor- to-good" patterns of smoke containment by Tom Smith. However, these tests are only used as indicators of containment. When satisfactory results are observed, they should be followed by tracer gas testing.

2) Tracer gas testing is the most reliable test for determining a fume hood's containment performance. A highly generalized overview of the test is provided. The gas most typically used is sulfur hexafluoride, or SF6. This gas flows into a fume hood being tested through a specially constructed "ejector." The ASHRAE 110 guideline includes engineering drawings to fabricate this ejector. SF6 flow rate is set at four liters per minute. The ejector is placed in different positions (center, left, and right) in the hood. A mannequin is placed in front of the hood being tested to simulate an operator. An inlet port to a detector device is placed at the "breathing zone" (the nose) of the mannequin. Tracer gas is allowed to flow for five minutes and spillage levels are recorded by the detector. Ratings can be provided for a hood at three levels of installation:

    - "As manufactured"—initial test of performance in a highly controlled/idealized setting at the manufacturer's facility.
    - "As installed"—testing is completed in the actual, fully operating facility, potentially more difficult conditions than the manufacturers' facility.
    - "As used"—testing is performed by adding a hood operator's experimental equipment, a.k.a., "clutter," to the "as installed" hood, making the test conditions even more difficult.

Test Apparatus

Miran 1A setup.

Acceptability Level

Testing criterion used is from ANSI/AIHA Standard Z9.5 (1992) for the "as installed" designation for the situation in the test/fabrication laboratory. The acceptability level required for AI designation is 0.1 PPM or less for five minute average at three mannequin positions; left, center, and right. Note that the more stringent "as manufactured" designation was also noted in test results. In this case, AM designation is 0.05 PPM or less for five minute average at three mannequin positions.

Deviations from ASHRAE 110 Containment Test Procedure

Face velocity tests were not performed. Optional sash movement and edge tracer gas tests were not performed.

Exception Report

The tracer gas test in left side of hood had the mannequin's arms inserted into the hood's sash opening making this a more stringent, non-standard test.

Containment Test Results

Test instrument used to detect SF6 was a Foxboro Miran 1A without an inlet filter. Inlet tube located at nose of mannequin. Calibrated with known sources of SF6 in "cal bags." Conversion factor of 0.110 PPM was equal to 0.055 volts, therefore concentration is equal to two times voltage from VOM.

Total Exhaust based on standard hood flowing at 100 FPM face velocity through the open sash area. Open sash area Berkeley Alpha hood is equal to 7.76 square feet x 100 FPM = 776 CFM. Hood was exhausting at 313 CFM, therefore 40 percent of standard hood. Measured by pitot tube and differential pressure meter.

Supply flows were set at the flowing values measured by "critical orifice" pressure drop measured by differential pressure meter. Airflow velocity from supply grill/screens were also measured with hot wire anemometer as follows:

1) Top Plenum: 73 to 75 CFM (average 70 FPM screen velocity).
2) Front Plenum: 63 to 67 CFM (average 70 FPM screen velocity).
3) Lower (bottom) Plenum: 96 to 97 CFM (average 70 FPM grill velocity).

Summary of Results

As noted, the prototype hood passed in all tests performed. Note that tracer gas test in left side of hood had the mannequin's arms inserted into the hood's sash opening making this a more stringent, non-standard test.

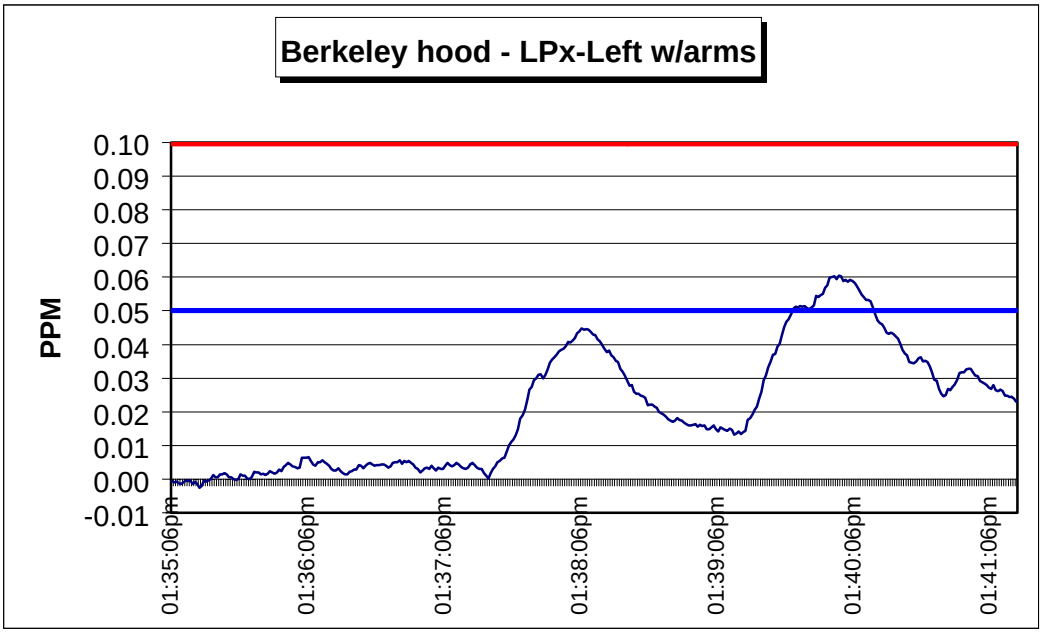
Test Type	Total Exhaust*	Containment	Aver. PPM	Max. PPM
Smoke – Large Volume	40%	Good	NA	NA
Smoke – Small Volume Edge	40%	Good	NA	NA
Tracer Gas – SF6 – Left (w/arms)	40%	Pass	0.021	0.060
Tracer Gas – SF6 – Center	40%	Pass	0.008	0.020
Tracer Gas – SF6 – Right	40%	Pass	0.003	0.010

*Total Exhaust based on standard hood flowing at 100 FPM face velocity through the open sash area. Open sash area Berkeley Alpha hood is equal to 7.76 square feet x 100 FPM = 776 CFM. Hood was flowing at 313 CFM, therefore 40 percent of standard hood.

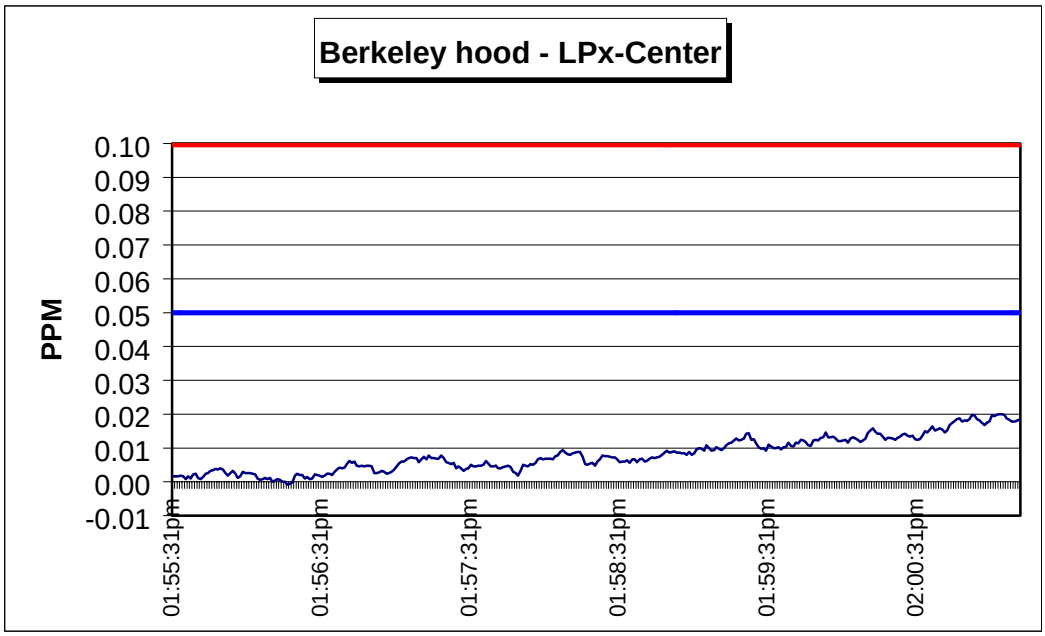
Plots of SF6 Tracer Gas Containment

The following are plots of the SF6 tracer gas runs that lasted for five minutes duration. Note that the more demanding designation of AM is accomplished in each test run, on average. In Plot 1, an added challenge of inserting the mannequin's arms into the hood was overcome.

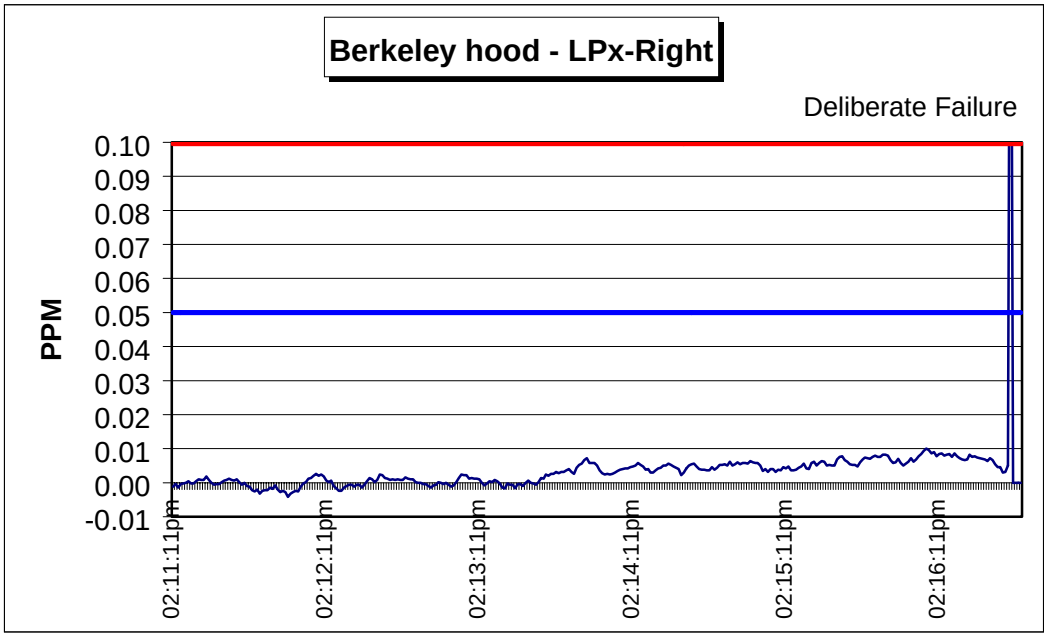
Plot 1



Plot 2



Plot 3



Acknowledgment

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